Integrated geophysics for mapping soil depth and rock quality in underwater passages

Test of fiber optics

Integrerad geofysik för kartläggning av jorddjup och bergkvalitet i vattenpassager

Test av optisk fiber

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Project aims and goals

The project is a feasibility test of Distributed Acoustic Sensing (DAS) as sensors for mid-scale underwater seismic surveys.

Specific goals:

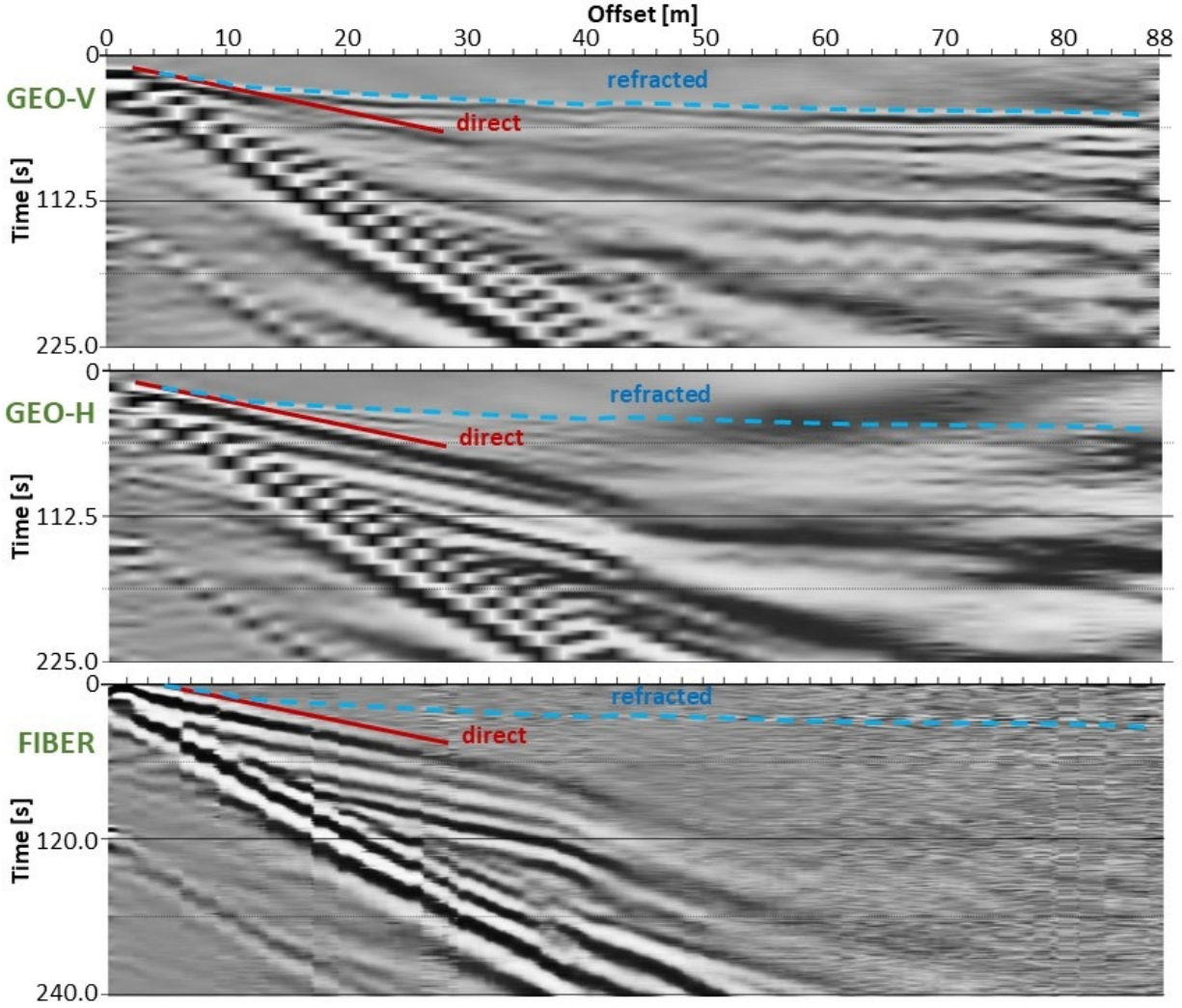
- Compare fiber optic sensors (DAS) with traditional geophones and hydrophones;
- Analyze the spectral content of the recordings of both sensors;
- Evaluate the possibility of recording refracted events in underwater surveys.

Project development:
On-land survey at the European Spallation Source site (Lund).

Pictures of the installation of the fibre optic cable in the ground: left, digging of the trench; middle, cable on top of sand layer; right, backfilling of the ditch with sand and excavated material.

Example of geophones layout with 0.5 m spacing and 4.5 Hz geophones. Yellow receivers are the vertical component geophones, while the red ones are the horizontal (in-line) component geophones.

Project development:
On-land survey at the European Spallation Source site (Lund).



Seismograms from Layout 1 (2 m geophone spacing) of (from top to bottom): vertical geophones (GEO-V), horizontal in-line geophones (GEO-H) and fiber optic sensors (FIBER).
Direct and refracted waves are highlighted by solid red lines and blue dashed lines, respectively.
The refracted event is not visible in the Fiber (DAS) acquisition and barely identifiable in the GEO-H geophones (as expected).

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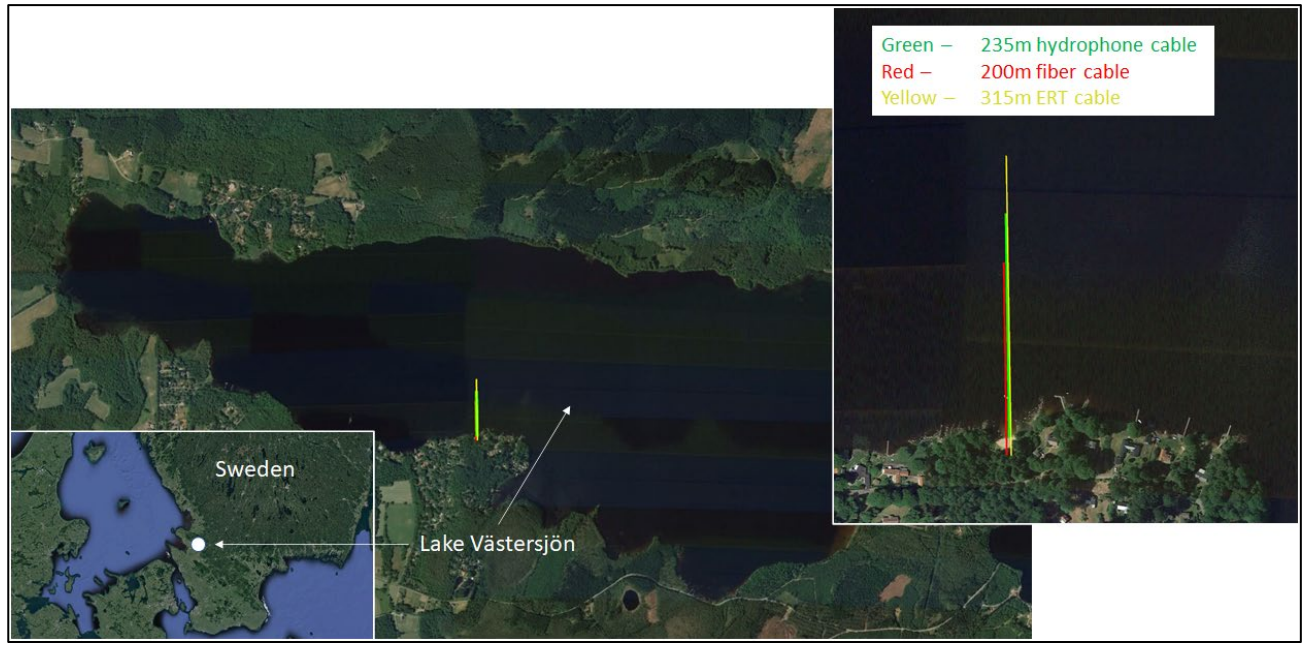
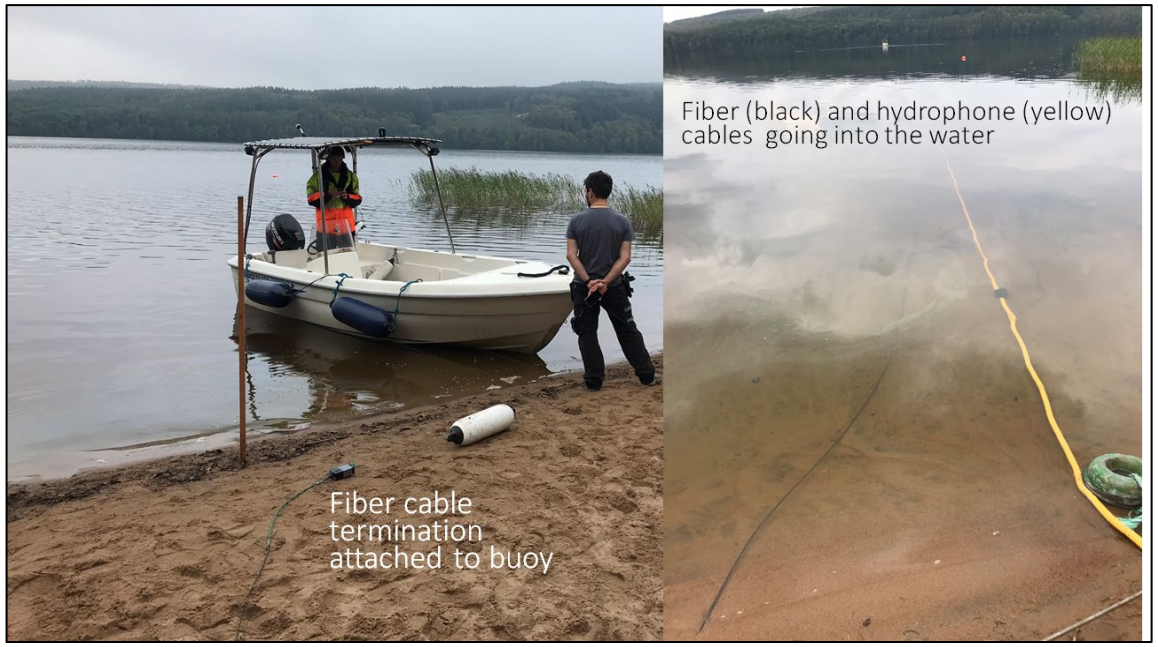
Project development:
Underwater survey at lake Västersjön.

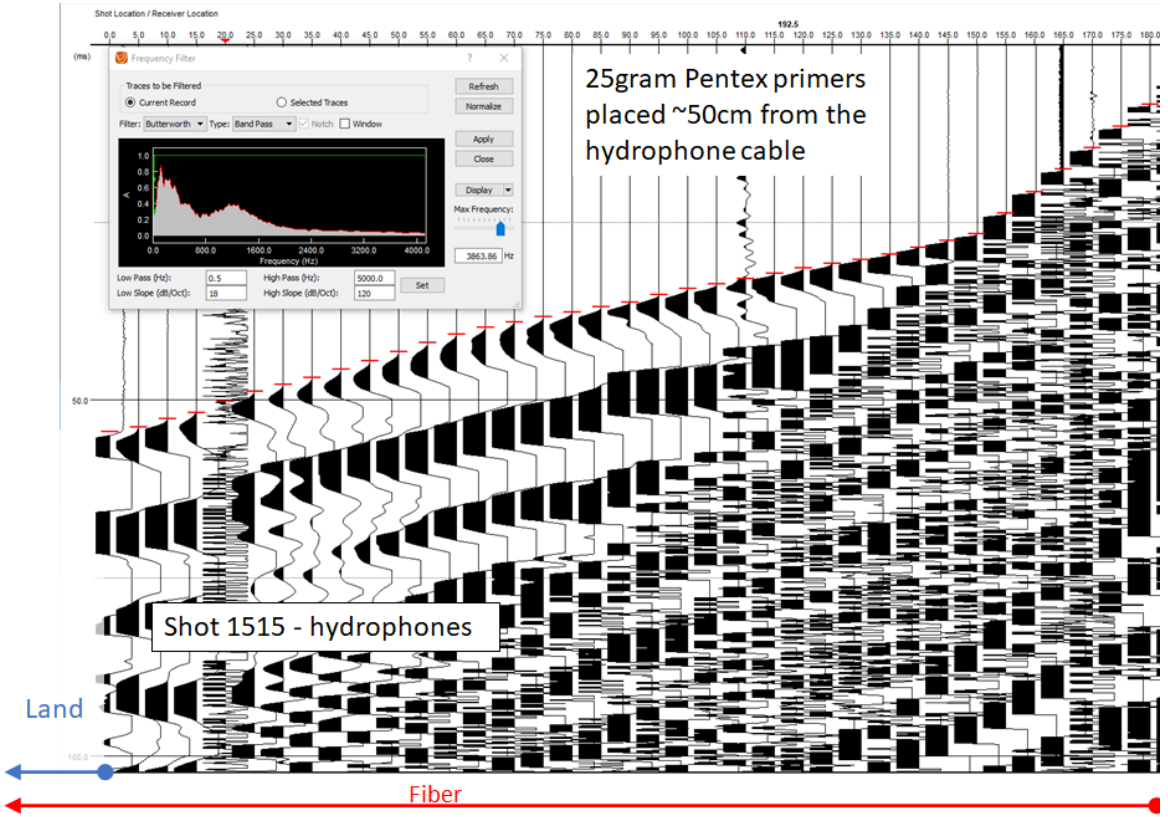


The place of lake Västersjön in southern Sweden and the position of the investigations in the lake.

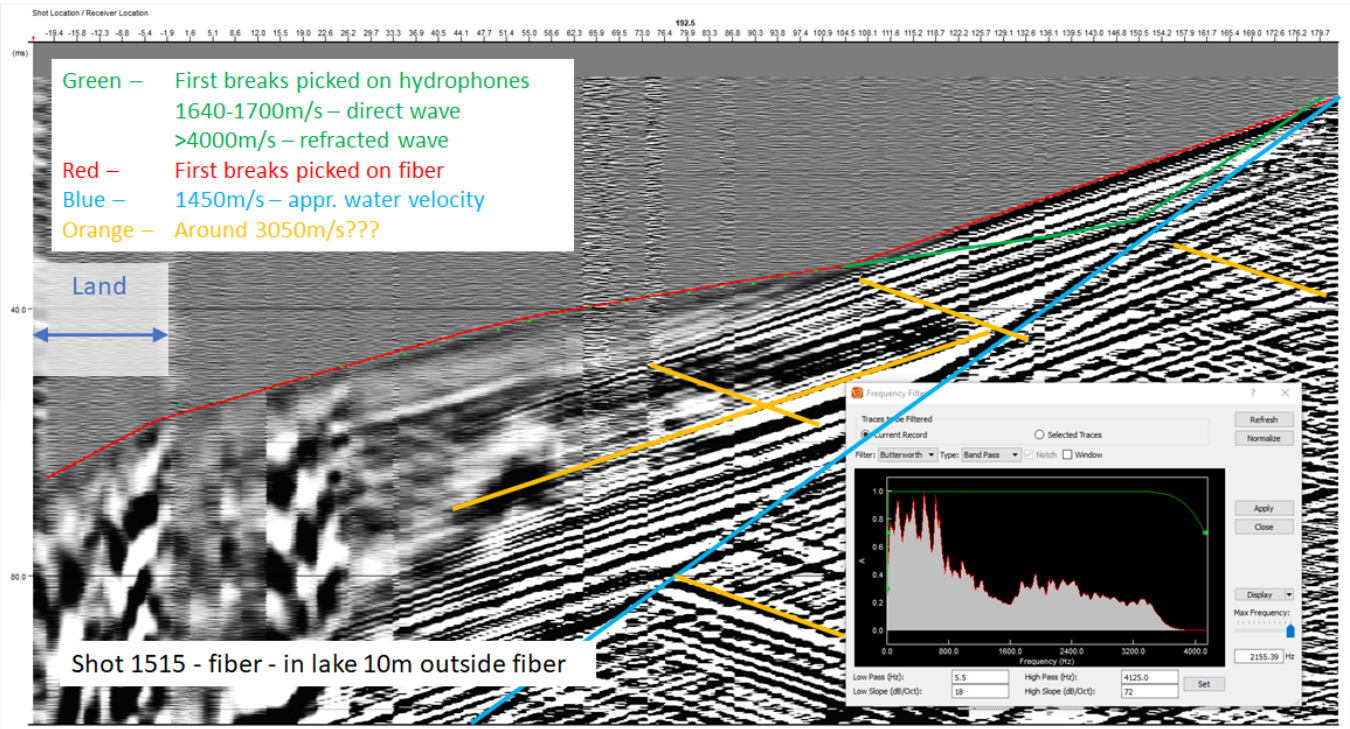


Workboat and placement of the seismic cables close to shoreline.

Project development:
Underwater survey at lake Västersjön.



A seismogram presenting hydrophone data for shot 1515. The picked first breaks for the direct and refracted wave are shown by red dashes. A frequency spectrum (from 0 Hz to approximately 4100 Hz) is shown in the upper left corner.



Seismogram presenting fiber data for shot 1515. The picked first breaks are shown with a red line. A frequency spectrum (from 0 Hz to approximately 4100 Hz) is shown in the lower right corner. The green line presents first breaks from the hydrophone data. The blue line presents the direct wave in the water. The orange lines present some of the strong wave events that is not present in the hydrophone data.

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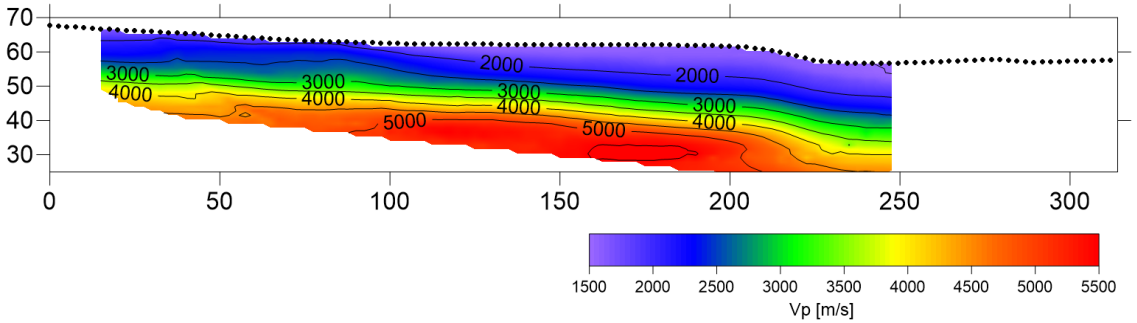
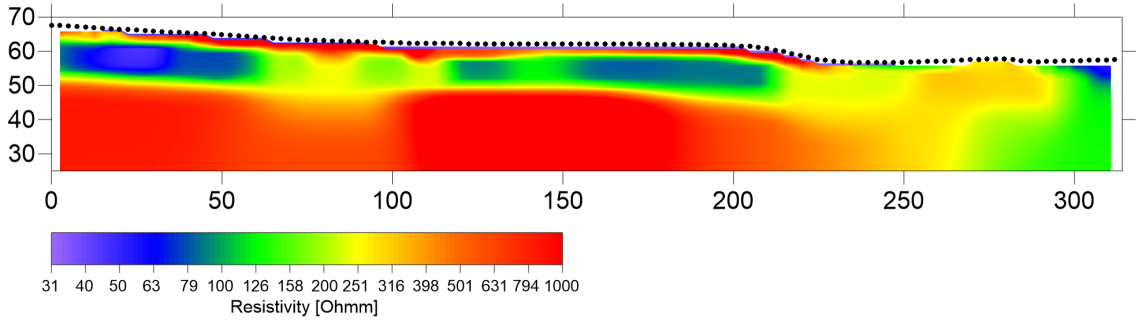
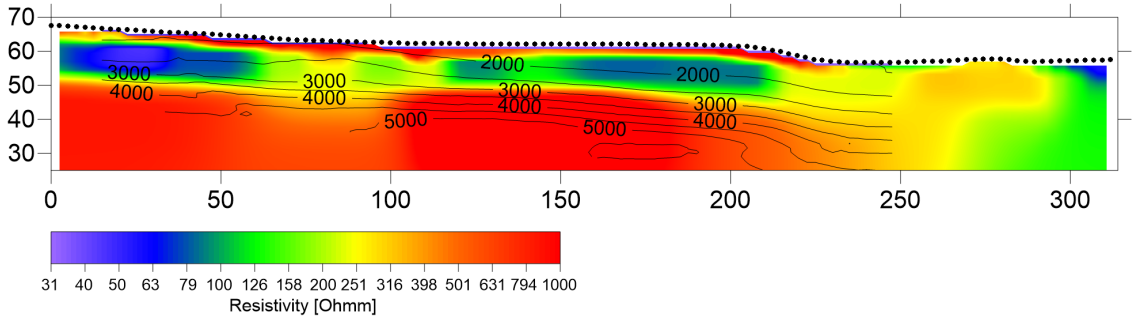
Project development:
Underwater survey at lake Västersjön.



Refraction tomography of the hydrophone data.



Resistivity profile from inverse modelling of gradient configuration data



Resistivity profile from inverse modelling of gradient configuration data with P-wave velocities from the refraction tomography.

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Conclusions

- DAS data for a fiber buried on land display a higher similarity with the horizontal in-line component of the geophones.
- In the underwater experiment, the signal from DAS is analogous to standard seismic receivers and contains refracted P-wave energy that compares very well with the hydrophone data.
- The fiber optic cable placed on the lake bed without further coupling can sense refracted seismic waves.
- The direct wave and the refracted signal of DAS is partially masked by a high-magnitude event with a constant velocity of about 3050 m/s, due to the resonance of the fiber cable itself.
- Further tests need to be done in order to show if fiber can also sense the direct wave in underwater surveys and decide which type of fiber is the best sensor for underwater measurements.